

1    CLAIMS

2    What is claimed is:

3    1. A substrate, comprising:  
4         a substrate having a recessed area on a surface thereof; and  
5         a heat sink comprising heat sink material deposited within the recessed area, the  
6                 heat sink material having thermal conductivity greater than thermal conductivity  
7                 of the substrate.

8    2. The apparatus of Claim 1, wherein the heat sink has a substantially flat surface  
9         substantially flush with the surface of the substrate.

10   3. The apparatus of Claim 1, further comprising a planar optical waveguide formed on  
11         the substrate and positioned so as to enable optical coupling between the planar  
12         optical waveguide and an optical device mounted on the substrate in thermal  
13         contact with the heat sink.

14   4. The apparatus of Claim 3, further comprising an optical device mounted on the  
15         substrate in thermal contact with the heat sink and positioned for optical coupling  
16         with the planar optical waveguide.

17   5. The apparatus of Claim 1, further comprising an electrical contact formed on the  
18         substrate and positioned so as to establish electrical continuity with an optical  
19         device mounted on the substrate in thermal contact with the heat sink.

20   6. The apparatus of Claim 5, further comprising an optical device mounted on the  
21         substrate in thermal contact with the heat sink and with electrical continuity  
22         established with the electrical contact.

23   7. The apparatus of Claim 5, wherein the electrical contact is positioned on at least a  
24         portion of the heat sink surface so as to provide thermal contact between the heat  
25         sink and an optical device mounted on the substrate so as to establish electrical  
26         continuity with the electrical contact.

27   8. The apparatus of Claim 7, further comprising solder for establishing electrical  
28         continuity between the optical device and the electrical contact and thermal contact  
29         between the optical device and the heat sink.

- 1        9. The apparatus of Claim 1, wherein the substrate includes a low-index optical buffer  
2              layer on the surface thereof, the optical buffer layer leaving exposed at least a  
3              portion of a surface of the heat sink.
- 4        10. The apparatus of Claim 1, wherein the substrate comprises silicon with a silica  
5              optical buffer layer on the surface thereof, and the heat sink material comprises  
6              diamond.
- 7        11. The apparatus of Claim 1, wherein the substrate comprises silicon, and the heat  
8              sink material comprises diamond.
- 9        12. The apparatus of Claim 1, further comprising a heat-generating device mounted on  
10             the substrate in thermal contact with the heat sink.
- 11      13. A method comprising:  
12              forming a recessed area on a surface of a substrate; and  
13              depositing heat sink material within the recessed area to form a heat sink, the heat  
14              sink material having thermal conductivity greater than thermal conductivity of  
15              the substrate.
- 16      14. The method of Claim 13, further comprising polishing the substrate and the heat  
17              sink material to form a substantially flat surface of the heat sink substantially flush  
18              with the surface of the substrate.
- 19      15. The method of Claim 13, further comprising forming a planar optical waveguide on  
20              the substrate positioned so as to enable optical coupling between the planar optical  
21              waveguide and an optical device mounted on the substrate in thermal contact with  
22              the heat sink.
- 23      16. The method of Claim 15, further comprising mounting an optical device on the  
24              substrate in thermal contact with the heat sink and positioned for optical coupling  
25              with the planar optical waveguide.
- 26      17. The method of Claim 13, further comprising forming an electrical contact on the  
27              substrate positioned so as to establish electrical continuity with an optical device  
28              mounted on the substrate in thermal contact with the heat sink.

- 1        18. The method of Claim 17, further comprising mounting an optical device on the  
2                substrate in thermal contact with the heat sink and with electrical continuity  
3                established with the electrical contact.
- 4        19. The method of Claim 17, wherein the electrical contact is positioned on at least a  
5                portion of the heat sink surface so as to provide thermal contact between the heat  
6                sink and an optical device mounted on the substrate so as to establish electrical  
7                continuity with the electrical contact.
- 8        20. The apparatus of Claim 19, further comprising applying solder for establishing  
9                electrical continuity between the optical device and the electrical contact and  
10              thermal contact between the optical device and the heat sink.
- 11      21. The method of Claim 13, further comprising forming a low-index optical buffer layer  
12              on the surface of the substrate, while leaving exposed at least a portion of a surface  
13              of the heat sink.
- 14      22. The method of Claim 13, wherein the substrate comprises silicon with a silica  
15              optical buffer layer on the surface thereof, and the heat sink material comprises  
16              diamond.
- 17      23. The method of Claim 13, wherein the substrate comprises silicon, and the heat sink  
18              material comprises diamond.
- 19      24. The method of Claim 13, further comprising mounting a heat-generating device onto  
20              the substrate in thermal contact with the heat sink.
- 21      25. A method comprising:  
22              forming multiple recessed areas on a surface of a substrate wafer; and  
23              depositing heat sink material within the multiple recessed areas to form multiple  
24              corresponding heat sinks, the heat sink material having thermal conductivity  
25              greater than thermal conductivity of the substrate wafer.
- 26      26. The method of Claim 25, further comprising polishing the substrate wafer and the  
27              heat sink material to form substantially flat surfaces of the multiple heat sinks  
28              substantially flush with the surface of the substrate wafer.

- 1    27. The method of Claim 25, further comprising forming multiple planar optical  
2       waveguides on the substrate wafer positioned so as to enable optical coupling  
3       between one of the planar optical waveguides and an optical device mounted on the  
4       substrate wafer in thermal contact with a corresponding one of the multiple heat  
5       sinks.
- 6    28. The method of Claim 27, further comprising:  
7       dividing the substrate wafer into multiple substrate segments, each having at least  
8       one corresponding heat sink and at least one corresponding planar waveguide;  
9       and  
10      mounting corresponding optical devices on the substrate segments in thermal  
11       contact with the corresponding heat sink and positioned for optical coupling with  
12       the corresponding planar optical waveguide.
- 13    29. The method of Claim 25, further comprising forming multiple electrical contacts on  
14       the substrate wafer positioned so as to establish electrical continuity with an optical  
15       device mounted on the substrate wafer in thermal contact with a corresponding one  
16       of the multiple heat sinks.
- 17    30. The method of Claim 29, further comprising:  
18       dividing the substrate wafer into multiple substrate segments, each having at least  
19       one corresponding heat sink and at least one corresponding electrical contact;  
20       and  
21      mounting corresponding optical devices on the substrate segments in thermal  
22       contact with the corresponding heat sink and with electrical continuity  
23       established with the corresponding electrical contact.
- 24    31. The method of Claim 29, wherein the multiple electrical contacts are positioned on  
25       at least a portion of surfaces of the corresponding heat sinks so as to provide  
26       thermal contact between the corresponding heat sink and an optical device  
27       mounted on the substrate wafer so as to establish electrical continuity with the  
28       corresponding electrical contact.

- 1        32. The apparatus of Claim 31, further comprising applying solder for establishing
- 2                electrical continuity between optical devices and the multiple electrical contacts and
- 3                thermal contact between optical devices and the multiple heat sinks.
- 4        33. The method of Claim 25, further comprising forming a low-index optical buffer layer
- 5                on the surface of the substrate wafer, while leaving exposed at least portions of
- 6                surfaces of the multiple heat sinks.
- 7        34. The method of Claim 25, wherein the substrate wafer comprises silicon with a silica
- 8                optical buffer layer on the surface thereof, and the heat sink material comprises
- 9                diamond.
- 10      35. The method of Claim 25, wherein the substrate wafer comprises silicon, and the
- 11                heat sink material comprises diamond.